Notice of Allowability	Application No.	Applicant(s)	
	09/489,878	DAS, MANUVIR	
	Examiner	Art Unit	
	Insun Kang	2193	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *8/8/2005*.

2. ☒ The allowed claim(s) is/are *1-36 and 52-56*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Ryan Grace (Reg. 52, 956) on 11/10/2005.

The application has been amended as follows:

Claim 1 (currently amended): A computer-implemented method for enhancing pointer analysis, the method comprising:

processing an assignment statement between two variables in a program, wherein processing ~~an~~ the assignment statement includes forming a relationship between two locations that are related to the two variables, wherein the two locations are selected to be one level of indirection away from a level associated with the assignment statement, wherein each location includes a label and a content; ~~and~~

defining a flow edge at the one level of indirection away from the level associated with the assignment statement;

associating ~~a~~ the flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations; and

selectively unifying the content of the first one of the two locations with the content of the second one of the two locations.

Claim 2 (currently amended): The computer-implemented method of claim 1, wherein the act of propagating is delayed for a predetermined period of time so as to allow the act of processing an assignment to be executed for each assignment in the program.

Claim 3 (currently amended): The computer-implemented method of claim 1, further comprising forming a points-to graph by iterating the act of processing an assignment for each assignment in the program.

Claim 4 (currently amendment): The computer-implemented method of claim 3, wherein forming the points-to graph includes forming a plurality of nodes, and forming a flow line between two nodes so as to represent the relationship between the two locations.

Claim 5 (currently amended): A computer readable medium having instructions stored thereon for causing a computer to perform a method for enhancing pointer analysis, the method comprising:

processing an assignment statement between two variables in a program, wherein processing an assignment statement includes forming a relationship between two locations that are related to the two variables, wherein the two locations are selected to be one level of indirection away from a level associated with the assignment statement , wherein each location includes a label and a content; ~~and~~

defining a flow edge at the one level of indirection away from the level associated with the assignment statement;

associating ~~a~~ the flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations; and

selectively unifying the content of the first one of the two locations with the content of the second one of the two locations.

Claim 6 (currently amended): A computer-implemented method of analyzing pointers in a program, the method comprising:

forming a location for at least one variable in the program, wherein the location includes a label and a content;

defining a relationship between two locations upon an assignment statement in the program, wherein the two locations are selected to be one level of indirection away from a level associated with the assignment statement; ~~and~~

defining a flow edge at the one level of indirection away from the level associated with the assignment statement;

associating ~~a~~ the flow edge with the first one of two locations and the second one of two locations, wherein the flow edge associates a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations; and

selectively unifying contents of the two locations.

Claim 7 (currently amended): The computer-implemented method of claim 6, further comprising propagating the label of the first one of the two locations to the second one of the two locations so as to make the label of the first one of the two locations a subset of the label of the second one of the two locations.

Claim 8 (currently amended): The computer-implemented method of claim 6, wherein forming the location includes forming a location that points to another location, and wherein the other location defines a pointed-to location of the location.

Claim 9 (currently amended): The computer-implemented method of claim 8, further comprising defining at least one level of indirection, wherein the at least one level of indirection is defined by at least one location, wherein a pointed-to location of the at least one location defines another level of indirection.

Claim 10 (currently amended): The computer-implemented method of claim 9, wherein defining the relationship includes defining a relationship between the two locations that are in the same level of indirection.

Claim 11 (currently amended): The computer-implemented method of claim 9, wherein defining the relationship includes defining a relationship between the two locations that are in different levels of indirection.

Claim 12 (Currently amended): A computer-implemented method of analyzing pointers in a program, the method comprising:

forming at least one location for at least one variable in the program, wherein the at least one location includes a label and a content;

forming a relationship between two locations upon an assignment statement of a first variable and a second variable in the program, wherein the two locations are selected to be one level of indirection away from a level associated with the assignment statement; ~~and~~

defining a flow edge at the one level of indirection away from the level associated with the assignment statement;

associating ~~a~~ the flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations; and

selectively unifying contents of the two locations.

Claim 13 (currently amended): The computer-implemented method of claim 12, wherein forming the location includes forming the location such that the location points to another location, and wherein the other location defines a pointed-to location of the location.

Claim 14 (currently amended): The computer-implemented method of claim 13, wherein forming the relationship between two locations includes forming the relationship between two

locations upon an assignment of a first variable and a second variable, wherein the second variable is assigned to the first variable.

Claim 15 (currently amended): The computer-implemented method of claim 14, wherein forming the at least one location includes forming a third location for the first variable and forming a fourth location for the second variable, wherein the third location points to the first location, and wherein the second location points to the second location.

Claim 16 (currently amended): The computer-implemented method of claim 15, further comprising determining that the program is well typed given that the second variable is assigned to the first variable if and only if a label of a pointed-to location of the second location is a subset of a label of a pointed-to location of the first location, and wherein a content of the pointed-to location of the first location is selectively unified with a content of the pointed-to location of the second location.

Claim 17 (Currently amended): A computer-implemented method of analyzing pointers in a program, the method comprising:

forming a location for at least one variable in the program, wherein the location includes a label and a content;

forming a relationship between two locations upon an assignment statement of a first variable and an address of a second variable in the program, wherein the two locations are selected to be one level of indirection away from a level associated with the assignment statement; ~~and~~

defining a flow edge at the one level of indirection away from the level associated with the assignment statement;

associating ~~a~~ the flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations; and

selectively unifying contents of the two locations.

Claim 18 (currently amended): The computer-implemented method of claim 17, wherein forming the location includes forming the location such that the location points to another location, and wherein the other location defines a pointed-to location of the location.

Claim 19 (currently amended): The computer-implemented method of claim 18, wherein forming the relationship between two locations includes forming the relationship between two locations upon an assignment of a first variable and a second variable, wherein the second variable is assigned to the first variable.

Claim 20 (currently amended): The computer-implemented method of claim 19, wherein forming the location includes forming a third location for the first variable and forming a fourth location for the second variable, wherein the third location points to the first location, and wherein the second location points to the second location.

Claim 21 (currently amended): The computer-implemented method of claim 20, further comprising determining that the program is well typed given that the address of the second variable is assigned to the first variable if and only if a label of the fourth location is a subset of a label of a pointed-to location of the third location, and wherein a content of the pointed-to location of the third location is selectively unified with a content of the fourth location.

Claim 22 (currently amended): A computer-implemented method of analyzing pointers in a program, the method comprising:

forming a location for at least one variable in the program, wherein the location includes a label and a content;

forming a relationship between two locations upon an assignment statement of a first variable and a dereference of a second variable in the program, wherein the two locations are selected to be one level of indirection away from a level associated with the assignment statement; ~~and~~

defining a flow edge at the one level of indirection away from the level associated with the assignment statement;

associating ~~a~~ the flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations; and

selectively unifying contents of the two locations.

Claim 23 (currently amended): The computer-implemented method of claim 22, wherein forming the location includes forming the location such that the location points to another location, and wherein the other location defines a pointed-to location of the location.

Claim 24 (currently amended): The computer-implemented method of claim 23, wherein forming the relationship between two locations includes forming the relationship between two locations upon an assignment of a first variable and a second variable, wherein the second variable is assigned to the first variable.

Claim 25 (currently amended): The computer-implemented method of claim 24, wherein forming the location includes forming a third location for the first variable and forming a fourth location for the second variable, wherein the third location points to the first of the two locations, wherein the fourth location points to a first pointed-to location, and wherein the first pointed-to location points to the second of the two locations to define a second pointed-to location.

Claim 26 (currently amended): The computer-implemented method of claim 25, further comprising determining that the program is well typed given that the dereference of the second variable is assigned to the first variable if and only if a label of the second pointed-to location is a subset of a label of a pointed-to location of the first location, and wherein a content of the pointed-to location of the third location is selectively unified with a content of the second pointed-to location.

Claim 27 (currently amended): A computer-implemented method of analyzing pointers in a program, the method comprising:

forming a location for at least one variable in the program, wherein the location includes a label and a content;

forming a relationship between two locations upon an assignment statement of a dereference of a first variable and a second variable in the program, wherein the two locations are selected to be one level of indirection away from a level associated with the assignment statement; ~~and~~

defining a flow edge at the one level of indirection away from the level associated with the assignment statement;

associating ~~a~~ the flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations; and

selectively unifying contents of the two locations.

Claim 28 (currently amended): The computer-implemented method of claim 27, wherein forming the location includes forming the location such that the location points to another location, and wherein the other location defines a pointed-to location of the location.

Claim 29 (currently amended): The computer-implemented method of claim 28, wherein forming the relationship between two locations includes forming the relationship between two locations upon an assignment of a first variable and a second variable, wherein the second variable is assigned to the first variable.

Claim 30 (currently amended): The computer-implemented method of claim 29, wherein forming the location includes forming a third location for the first variable and forming a fourth location for the second variable, wherein the third location points to a pointed-to location that points to the second of the two locations to define a first pointed-to location, wherein the fourth location points to the first of the two locations.

Claim 31 (currently amended): The computer-implemented method of claim 30, further comprising determining that the program is well typed given that the second variable is assigned to the dereference of the first variable if and only if a label of a pointed-to location of the fourth location is a subset of a label of the first pointed-to location, and wherein a content of the first pointed-to location is selectively unified with a content of the pointed-to location of the fourth location.

Claim 32 (currently amended): A computer readable medium having instructions stored thereon for causing a computer to perform a method of analyzing pointers in a program, the method comprising:

forming a location for at least one variable in the program, wherein the location includes a label and a content;

defining a relationship between two locations upon an assignment statement in the program, wherein the two locations are selected to be one level of indirection away from a level associated with the assignment statement; ~~and~~

defining a flow edge at the one level of indirection away from the level associated with the assignment statement;

associating ~~a~~ the flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations; and

selectively unifying contents of the two locations.

Claim 52 (currently amended): A computer-implemented method for enhancing pointer analysis, the method comprising:

processing a plurality of assignment statements between variables in a program to derive a plurality of sets of information, wherein the plurality of sets of information is distributed among a plurality of levels of indirection; ~~and~~

establishing a plurality of flow relationships between locations that are related to the variables corresponding to each of the plurality of assignment statements, wherein each of the

flow relationships is selected to be established one level of indirection away from each of the assignment statements, and wherein the flow relationship includes a flow edge defined at the one level of indirection away from the level associated with the assignment statements and configured to propagate a label such that the label of one of the plurality of sets of information is a subset of another of the plurality of sets of information; and

selectively unifying at least one of the sets of information in at least one level of indirection as at to allow a desired level of analytical precision within a desired duration of pointer analysis.

Claim 53 (currently amended): The computer-implemented method of claim 52, wherein the act of selectively unifying includes unifying sets of information in all levels of indirection except for a first level of indirection.

Claim 54 (currently amended): The computer-implemented method of claim 52, wherein the desired duration of pointer analysis is linearly proportional to the size of the program.

Claim 55 (currently amended): A computer system having a processor and memory for enhancing pointer analysis of a program, wherein the program includes at least one source file, the system comprising:

a compiler to compile the at least one source file to produce an intermediate language;

a builder receptive to the intermediate language to build a tree that represents the at least one source file; and

an analyzer to analyze the tree to produce an object file, wherein the object file contains at least one relationship between two locations that are related to two variables in an assignment statement in the program, wherein the relationship includes a flow edge that defines that a set of symbols relating to one of the two variables is a subset of a set of symbols relating to the other of the two variables, ~~and~~ wherein the relationship is selectively formed one level of indirection away from a level associated with the assignment statement between the set of symbols related to one of the two variables and the set of symbols relating to the other of the two variables; and wherein contents of the two locations are selectively unified.

These amendments were necessary in order to further clarify the claims and obviate any rejection under 35 U.S.C. 112 1st and 2nd.

Examiner's Statement of Reason(s) for Allowance

2. Claims 1-36 and 52-56 (renumbered 1-41) are allowed.

3. The following is an examiner's statement of reason s for allowance:

The closest prior arts of record, i.e. Steensgaard and Andersen, taken alone or in combination, fail to teach or fairly suggest at least: two locations are selected to be one level of indirection away from a level associated with the assignment statement, associating a flow edge configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations; and selectively unifying contents of the two locations as recited in the independent claims.

Steensgaard discloses the bidirectional unification based pointer analysis at the top level, which results in almost linear running time but produces relatively imprecise results. Steensgaard does not select two locations to be one level of indirection away from a level associated with the assignment statement and does not associate the flow edge that defines the subset relationship. Andersen's subtyping algorithm produces more precise results but requires tracking of "the subtyping relations induced at all

levels of the points-to graph (remark filed 6/3/2005)." Andersen ultimately fail to teach selecting two locations to be one level of indirection away from a level associated with the assignment statement, associating a flow edge defined at the one level of indirection away from the level associated with the assignment statement; and then selectively unifying a content of a first one of the two locations with a content of a second one of the two locations. See also applicant's remark filed 8/8/2005 (pages 13-15).

4. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Insun Kang whose telephone number is 571-272-3724. The examiner can normally be reached on M-F 7:30-4 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kakali Chaki can be reached on 571-272-3719. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you

have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

I. Kang
Examiner
11/10/2005

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